REMOVAL OF PHOSPHORUS AND ALUMINIUM FROM RUBBER INDUSTRY WASTEWATER USING AGRO-WASTE BIOCHAR

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

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I hereby declare that the short synopsis entitled **REMOVAL OF PHOSPHORUS AND ALUMINIUM FROM RUBBER INDUSTRY WASTEWATER USING AGRO-WASTE BIOCHAR** being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in the Department of Sciences (Chemistry) under the School of Sciences of Manav Rachna University, Faridabad during the academic year 2025-26.

It is the work that is expected to be carried out under the supervision of Dr. Roopa Rani and co-supervision of Dr. AnoopYadav.

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ABSTRACT

In Industrial effluents, particularly from Rubber industries, Heavy metals like Phosphorus and Aluminum and other many harmful substances are found. They are harmful to human health and environment. Although many conventional wastewater treatment methods are used over many years to treat these pollutants but these traditional wastewater treatment methods are of high cost generates secondary wastes and requires a very high amount of energy. This research will be focused on the use of Biochar made from agriculture wastes as an effective, eco- friendly, economic and low cost adsorbent for the removal of Phosphorus and Aluminum from rubber industries waste water. Biochar will be produced using Pyrolysis process from agricultural waste such as cotton husk and mustard husk. Their Physicochemical characteristics can be studied by using different techniques such as SEM, XRD, FTIR, etc.

Batch adsorption tests will be tested for pH, temperature, contact time, biosorbent dosage, metal concentration. Further reusability of Biochar can be tested through working the used biochar with acid to remove the sorbed content and their reusing it for same adsorption process to the effluent of rubber industry and then characterizing the result. This research investigates an affordable way to treat this nutrient rich industrial effluent which helps in environment sustainability and waste management. The focus of this research work is to provide an eco-friendly approach to treat Industrial wastewater using biosorption techniques for absorption of Phosphorus and Aluminum.

Keywords: *Phosphorus, Aluminum, Biosorption, Biochar, SEM, XRD, FTIR, TGA*

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List of Abbreviations

Al – Aluminum

BOD – Biochemical Oxygen Demand

Cd – Cadmium

COD – Chemical Oxygen Demand

Cr – Chromium

Fe – Iron

FTIR – Fourier Transform Infrared Spectroscopy

GIS – Geographic Information System

Mg – Magnesium

Ni – Nickel

P – Phosphorus

Pb – Lead

pH – Potential of Hydrogen

ppm – Parts per million

SEM – Scanning Electron Microscopy

SMS – Spent Mushroom Substrate

TDS – Total Dissolved Solids

WHO – World Health Organization

XRD – X-Ray Diffraction

Zn – Zinc

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1. INTRODUCTION

1.1 Background of the study

Over 71% of Earth's surface is covered with water, but only 2.5% of it is freshwater and even that is largely inaccessible, as most of it is located away in the form of glaciers and icecaps. Available water is being used for many purposes and thus there is generation of large amount of wastewater too. From domestic wastes, industrial wastes, agriculture wastes almost 70% of surface water is unfit for human consumption which is most concerning situation across global. Industrial wastes are the largest source of Water Pollution. Industrial wastewater is generally released into surface water bodies like rivers, streams and oceans. This makes them more and more polluted with accumulation of several pollutants day by day. The present study deals with the analysis of rubber industry waste water of Bhiwadi region of Haryana state, India. (1) Here, the wastewater is frequently released in Sabi River without proper treatment, this causes a serious harm to our environment and agriculture land. Instead of their effective but expensive traditional wastewater treatment methods like chemical precipitation, membrane filtration, reverse osmosis they produces secondary sludges also which is harmful for ecosystem . Biosorption method employing biochar made from agriculture wastes provides a sustainable solution that is both environmentally and economically beneficial. In order to support environment sustainability, this work intends to investigate the potential of biosorption in reducing Industrial wastewater pollution from rubber Industry, with a specific emphasis on the removal of Phosphorus and Aluminum.

Fig.1: Water pollution in Sabi River in Bhiwadi due to Industrial water

1.2 Importance of Removing Phosphorus and Aluminumin Bhiwadi Industrial wastewater;

Excess of Phosphorus causes eutrophication, fast growth of algal blooms in water bodies near Bhiwadi mainly Sabi river. Phosphorus is a crucial nutrient that depletes oxygen, causes algal blooms, decreases

the water quality and makes it unsafe for aquatic life and ecosystem. To avoid ecological imbalance, phosphorus must be removed from water bodies. On the other hand, Aluminum is a toxic metal that mainly founds in rubber industrial wastewater, when Aluminum contained water goes in Sabi river it makes water acidic. Excess of Aluminum forms precipitates on fish gills that have a negatively effect on respiration process. Presence of excess Aluminum makes water ionic imbalance and leads to osmoregulation and fish mortality.

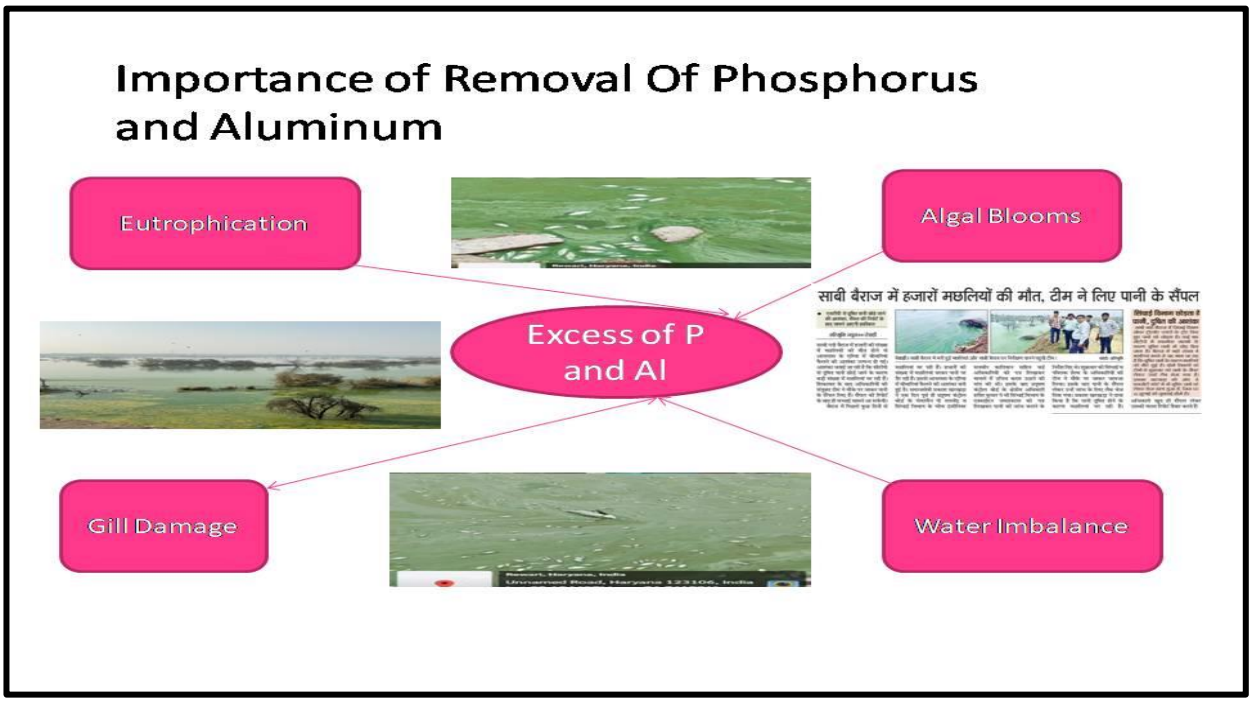

Fig.2: Impacts of Excess Phosphorus and Aluminum on aquatic system

1.3 Drawbacks of Conventional Treatment Methods

There are various analytical techniques to remove pollutants from wastewater. Some of the techniques conventionally used to treat wastewater are mentioned below in table 1 (2).

Table 1- Summary of Advantages and Limitations of Methods use for Pollutant Removal

Method	Description	Advantages	Limitations
Electrochemical Method	Redox reaction are used to remove heavy metals from wastewater , producing pure metal forms	for metal recovery shows high efficiency	Intensive energy, high operational costs
Membrane filtration	Semi permeable membrane used after	Compact design with high removal	frequent membrane fouling and high

	filtration of suspended solids , other impurities and heavy metals	efficiency	operation cost
Ion exchange method	Exchange of cations and anions in wastewater with natural materials	Effective for selective ion removal	Ph sensitivity
Chemical Precipitation	To precipitate heavy metals and chemicals as undissolved compounds for removal	Easy to implement and cost effective	Disposal issues, generates large volume of sludges
Reverse Osmosis	To remove solids particles by using a semi permeable membrane	Effective for dissolved salts and metals	Disposal problem, high operational and maintenance costs (3)

Although few Industries in Bhiwadi Region have adopted traditional methods to treat their wastewater before dispersing it to river but they are less viable. An economic and more relatable method must be identified and commercialized to remove toxicants from polluted water which can also reduces the burden of biomass waste from ecosystem. This study investigates the application of biosorption method as an environmentally and economical responsible technique for treating Industrial wastewater.

1.4 Biosorption as an Alternative Approach

Biosorption method is low cost method with no waste generation. This is a natural process of combining of biosorbent such as plant, animal or Microorganism based biosorbent used to remove heavy metals and pollutants from wastewater. Other traditional techniques can be associated with production of biological sludge as compared to biosorption method thereby making more effective and more environments friendly method for purification.

Biosorption having the property of being eco-friendly, cheaper, readily accessible and efficient at low concentrations have made this technique more suitable for wastewater treatment (4). Optimization of different factors for maximum biosorption shall be carried out with the following factors like pH, temperature (5).

1.5 Agro –Waste Biochar: A Sustainable Solution

Biochar is a solid formed through the thermo chemical conversion of biomass or carbonaceous material at temperature about more than 250°C in limited oxygen supply (6,7).

Biochar is a substance enriched with carbon content and:-

- Greater surface area.
- High porosity
- More functional groups on surface

These features help in adsorption of heavy metals and other pollutants from water (8).

The mechanism of heavy metal adsorption capacity of biochar is based on its physicochemical attributes like pore size, structure, extensive surface area and functional group (9).

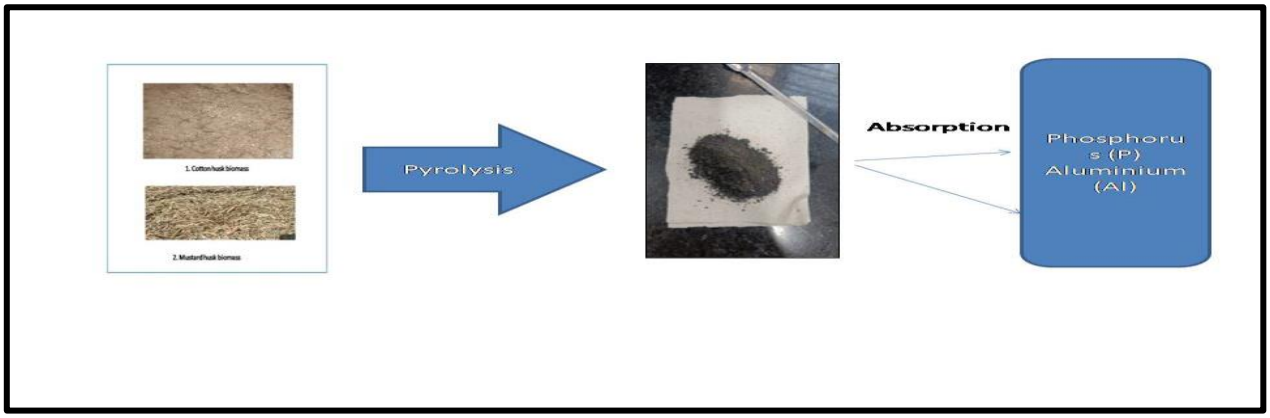

Fig. 3- Conversion of cotton and mustard husk into Biochar via pyrolysis for adsorption of Phosphorus and Aluminum

Bhiwadi being an Industrial hub produces large amount of wastewater, sewage sludge ,fly ash and other organic wastes . This can be easily pyrolyzed to biochar. The present study deals with the study of these agricultural wastes such as wheat straw, cotton husk, mustard husk can be transformed into biochar. Due to porous structure and active functional groups on biochar, these allow high adsorption of metals and non-metals like Phosphorus and Aluminum (10).

2. LITERATURE REVIEW

In this section of literature review, some important studies prepared for investigation are provided. It draws attention to previous studies on the pollutants present in Industrial effluents, with an emphasis on nutrients like Aluminum and Phosphorus and also heavy metals. Alerting amount of contaminants of Industrial effluents, surpassing permissible limit are found in studies from Bhiwadi and other Industrial zones, endangering human health, aquatic ecosystem and agriculture. Conventional wastewater treatment technologies are frequently expensive and produce more sludges and secondary wastes. From all over the

world, researchers have been proved that biosorption method by using agro-waste biochar for the removal of Phosphorus and Aluminum. In rubber sector effluents, it has been very necessary to find a sustainable solution for removal of Phosphorus and Aluminum. This research highlights, research gaps, key findings and discoveries.

Table 2- Summary of Literature on Wastewater pollution in Bhiwadi

Sr. No.	Study focus	Key findings	Relevant to this research	Research gaps	References
1.	Heavy Metals in Spinach (Bhiwadi wastewater)	High Cr levels exceeding WHO limits	Proves contamination of Industrial wastewater	Phosphorus and Aluminum not studied	Sharma Manju et al., 2014 (11)
2.	Physico-chemical parameters of wastewater in Bhiwadi	High BOD, COD ,TDS Fluoride levels in Industrial wastewater	Proves poor quality of water and unuseful for irrigation	No focus on Phosphorus or Aluminum	Yadav et al., 2012 (12)
3.	Groundwater contamination risk assessment using GIS in Bhiwadi	High Chromium concentration , toxic to health	Highlights groundwater contamination in Bhiwadi	No data on Aluminum and Phosphorus removal	Rajput et al.,2020 (13)
4.	Groundwater pollution overview in southwest Bhiwadi	Levels of Fluoride exceeds permissible limit	Industrial wastewater shows harmful impact on Water quality.	Phosphorus and Aluminum contamination not assessed	R.N et. al.2020(14)
5.	Potable water quality in Bhiwadi	High fluoride , Iron, TDS observed	Proves Industrial pollution of	Phosphorus and Aluminum not studied	Sharma et al., (2020) (15)

	Industrial Area	exceeding limits	water sources		
6.	Impact of Industrialization on Farmer's Health near Haryana Industrial Area	High fluoride and nitrate concentrations and found in water sources	Shows contamination affecting human health	No focus on Phosphorus and Aluminum	Yadav and Pandey ,2021 (16)
7.	Presence of Heavy Metals in Industrial Wastewater	Presence of Cr(IV), Pb (II) , Cd(II) , Ni (II), Zn(II)	Shows the need for heavy metal removal from wastewater	Phosphorus and Aluminum not discussed	Shijie, 2024(17)
8.	Biosorption Methods for Wastewater Treatment	Biosorption effective for metal removal using fungi, algae etc.	Promotes eco-friendly biosorption methods	Phosphorus and Aluminum not specifically	Goude and Toha , 2023 (18)
9.	Phosphorus removal using Biochar	Without pre-treatment biochar cannot absorb phosphorus	Shows potential of Biochar removal	Field application study limited, AlCl3 doping shows but not with other agents	Novais et al., 2018 (19)
10.	Mg/Fe biochar for phosphate removal	142.31mg P/g capacity, Langmuir-Freindlich model, stable upto 3 cycles	Biochar modification for phosphate removal	High alkalinity, no field trial study	Zhang et al., 2021(20)
11.	Removal of Aluminum from Water and Industrial	Activated carbon effectively removes Aluminum,	Highlights removal of Aluminum from Industrial	Phosphorus removal not addressed, agriculture	Pour, P. G.Takassi et al. (21)

	Wastewater	process is spontaneous , fast and endothermic	effluents	biochar as adsorbent not explored	
12.	Valorization of bio-waste for the removal of aluminum from industrial wastewater	Spent Mushroom substances (SMS) can remove >95% Aluminum ; output concentration <1ppm; optimum ph 5.9-6.5	Proves that agriculture waste (SMS) is effective for aluminum removal	Long-term field –scale application and color /BOD impact not studied	Corral - .Bobadrilla et al., 2020 (22)
13.	Agro-waste biochar & pyrolysis	600*C better adsorption , porous biochar	Biochar preparation methods	Low temperature biochar less effective	Gotore et al.,2024 (23)

It is clear from the above literature, there is a need to develop a method for the removal of Phosphorus and Aluminum, especially with the use of Biochar. Recent studies have focused more on heavy metals like chromium, lead, cadmium etc. This research focuses on reduced environmental hazards, advanced wastewater treatment methods using agriculture wastes.

3. DESCRIPTION OF THE TOPIC

This study overall focus on a sustainable solution on Industrial wastewater, particularly a strong emphasis on Phosphorus and Aluminum removal from the rubber industry wastewater. By Industrialization, water contamination has been widely exacerbated. Conventional wastewater treatment methods are ultimately ineffective, energy intensive and of high cost.

Biosorption by using Agro waste Biochar is an environmental friendly method substitutes that production of secondary waste sludge that is also highly efficient and low cost not so expensive.

This study highlights the use of biochar made from agriculture wastes or leftover things such as cotton husk and mustard husk.

For characterization and identify its physico-chemical properties, a variety of analytical methods such as SEM, FTIR, XRD will be used.

4. OBJECTIVES OF RESEARCH

1. Analyze wastewater from Bhiwadi's rubber industry for Phosphorus and Aluminum removal.
2. To prepare biochar from cotton and mustard husk and characterize its physico -chemical properties.
3. To evaluate the efficiency of Biochar in removing Phosphorus and Aluminum from Rubber Industry wastewater.
4. To conduct adsorption isotherm.

5. METHODOLOGY TO BE ADOPTED

(1) Collection of wastewater samples- Wastewater samples will be collect from a selected rubber industry in Bhiwadi. After selecting rubber industry wastewater will be collected from outlet point.

(2) Analysing wastewater- Wastewater samples will be analyzed to check the concentration of Phosphorus and Aluminum. Other pollutants level will also check in rubber industrial waste water.

(3) Collection of raw materials- Agriculture waste such as cotton husk and mustard husk will be collected locally. Allowed by washing using distilled water, after dried them in sunlight and will prepare them for biochar.

(4) Preparation of Biochar from Raw materials- Through pyrolysis Biochar will be produced from collected biomass under limited oxygen conditions in a muffle furnace. Prepared biochar will be ground, sieve and if needed physically and chemically modified by acid/base treatment.

(5) Characterization of Biochar- The physico-chemical properties of Biochar will be analyzed using Scanning Electron Microscopy (SEM), X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR).

(6) Batch adsorption experiments- To study the effects of parameters such as ph, contact time, initial metal concentration, and adsorbent dosage and temperature experiments will be conducted on the removal of phosphorus and aluminum.

6. EXPECTED OUTCOME OF THE RESEARCH

It is expected that this work would create an affordable, eco-friendly, effective techniques for removing phosphorus and aluminum from industrial wastewater from rubber sector. Due to the property of porous structure and active functional group, the produced biochar is expected to have a high adsorption capacity. It is anticipated that the adsorption process will adhere to Langmuir and Freindlich Isotherms, also demonstrating its suitability for treating the real wastewater world.

This study will also enhance green chemistry techniques, waste management, water pollution control by encouraging the use of agriculture waste products for environment rehabilitation.

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